Network Standard

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NW000-S0048 **NS194 SECONDARY SYSTEMS REQUIREMENTS FOR EMBEDDED GENERATORS**

ISSUE

For issue to all Ausgrid and Accredited Service Providers' staff involved with the connection of embedded generation to Ausgrid's network.

Ausgrid maintains a copy of this and other Network Standards together with updates and amendments on www.ausgrid.com.au.

Where this standard is issued as a controlled document replacing an earlier edition, remove and destroy the superseded document.

DISCLAIMER

As Ausgrid's standards are subject to ongoing review, the information contained in this document may be amended by Ausgrid at any time. It is possible that conflict may exist between standard documents. In this event, the most recent standard shall prevail.

This document has been developed using information available from field and other sources and is suitable for most situations encountered in Ausgrid. Particular conditions, projects or localities may require special or different practices. It is the responsibility of the local manager, supervisor, assured quality contractor and the individuals involved to make sure that a safe system of work is employed and that statutory requirements are met.

Ausgrid disclaims any and all liability to any person or persons for any procedure, process or any other thing done or not done, as a result of this Standard.

All design work, and the associated supply of materials and equipment, must be undertaken in accordance with and consideration of relevant legislative and regulatory requirements, latest revision of Ausgrid's Network Standards and specifications and Australian Standards. Designs submitted shall be declared as fit for purpose. Where the designer wishes to include a variation to a network standard or an alternative material or equipment to that currently approved the designer must obtain authorisation from the Network Standard owner before incorporating a variation to a Network Standard in a design.

External designers including those authorised as Accredited Service Providers will seek approval through the approved process as outlined in NS181 Approval of Materials and Equipment and Network Standard Variations. Seeking approval will ensure Network Standards are appropriately updated and that a consistent interpretation of the legislative framework is employed.

Notes: 1. Compliance with this Network Standard does not automatically satisfy the requirements of a Designer Safety Report. The designer must comply with the provisions of the Workplace Health and Safety Regulation 2011 (NSW - Part 6.2 Duties of designer of structure and person who commissions construction work) which requires the designer to provide a written safety report to the person who commissioned the design. This report must be provided to Ausgrid in all instances, including where the design was commissioned by or on behalf of a person who proposes to connect premises to Ausgrid's network, and will form part of the Designer Safety Report which must also be presented to Ausgrid. Further information is provided in Network Standard (NS) 212 Integrated Support Requirements for Ausgrid Network Assets.

2. Where the procedural requirements of this document conflict with contestable project procedures, the contestable project procedures shall take precedent for the whole project or part thereof which is classified as contestable. Any external contact with Ausgrid for contestable works projects is to be made via the Ausgrid officer responsible for facilitating the contestable project. The Contestable Ausgrid officer will liaise with Ausgrid internal departments and specialists as necessary to fulfil the requirements of this standard. All other technical aspects of this document which are not procedural in nature shall apply to contestable works projects.

INTERPRETATION

In the event that any user of this Standard considers that any of its provisions is uncertain, ambiguous or otherwise in need of interpretation, the user should request Ausgrid to clarify the provision. Ausgrid's interpretation shall then apply as though it was included in the Standard, and is final and binding. No correspondence will be entered into with any person disputing the meaning of the provision published in the Standard or the accuracy of Ausgrid's interpretation.

KEYPOINTS

This standard has a summary of content labelled "KEYPOINTS FOR THIS STANDARD". The inclusion or omission of items in this summary does not signify any specific importance or criticality to the items described. It is meant to simply provide the reader with a quick assessment of some of the major issues addressed by the standard. To fully appreciate the content and the requirements of the standard it must be read in its entirety.

AMENDMENTS TO THIS STANDARD

Where there are changes to this standard from the previously approved version, any previous shading is removed and the newly affected paragraphs are shaded with a grey background. Where the document changes exceed 25% of the document content, any grey background in the document is to be removed and the following words should be shown below the title block on the right hand side of the page in bold and italic, for example, Supersedes – document details (for example, "Supersedes Document Type (Category) Document No. Amendment No.").

KEY POINTS OF THIS STANDARD

Scope and Risks Addressed

This standard is principally intended to address the following risk:

- ☐ Damage to equipment and injury of people due to an unintended islanding event caused by embedded generation.

The scope of this standard includes:

- ☐ Anti-Islanding protection.
- ☐ Technical approval requirements for anti-islanding protection.
- ☐ Commissioning requirements for anti-islanding protection.
- ☐ Notes on select topics as relating to embedded generators, including earthing and voltage control requirements, which are in addition to more detailed requirements found in other Network Standards.

Where to for more information?

Chapters 1 and 2

Inverter Energy Systems

For an IES of 30kVA or less, key sections of this standard include:

- ☐ Chapter 7 – Inverter Energy Systems

For an IES of above 30kVA up to 200kVA, with a LV connection point, key sections of this standard include:

- ☐ Chapter 7 – Inverter Energy Systems
- ☐ Section 10.3 – Commissioning IES of greater than 30kVA, up to 200kVA

For an IES of above 30kVA up to 200kVA, with a HV connection point, key sections of this standard include:

- ☐ Chapter 7 – Inverter Energy Systems
- ☐ Section 9.6 – Neutral Voltage Displacement
- ☐ Section 10.4 – Commissioning of IES of above 200kVA, Rotating Machines, and HV Connected Installations

For an IES of above 200kVA, key sections of this standard include:

- ☐ Chapter 7 – Inverter Energy Systems
- ☐ Chapter 9 – Anti-Islanding Protection
- ☐ Section 10.4 – Commissioning of IES of above 200kVA, Rotating Machines, and HV Connected Installations

Tools and Forms

Annexures A, C through E

Rotating Machines

For rotating machine embedded generators of 30kVA or less, key sections of this standard include:

- ☐ Chapter 8 – Rotating Machines

For rotating machine embedded generators of above 30kVA, key sections of this standard include:

- ☐ Chapter 8 – Rotating Machines
- ☐ Chapter 9 – Anti-Islanding Protection
- ☐ Section 10.4 – Commissioning of IES of above 200kVA, Rotating Machines, and HV Connected Installations

Where to for more information?

NS194B Guidelines for Rotating Machines Connected to the Ausgrid Network

Tools and Forms

Annexures B through E

Multiple Generator Installations

Guidance for requirements of this standard for electrical installations with multiple generator types or existing generation is given in:

- ☐ Chapter 12 – Multiple Embedded Generation Systems

Where to for more information?

N/A

Tools and Forms

N/A

Network Standard
NS194
Secondary Systems Requirements for Embedded Generators

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1.0 PURPOSE

This standard prescribes the technical requirements for connection of embedded generation to Ausgrid's network. Its intent is to address possible adverse impacts of the embedded generation.

For information regarding the application process for connection of generators to Ausgrid's network please refer to Ausgrid's website.

2.0 SCOPE

This document outlines the secondary systems requirements for connection of embedded generation to the Ausgrid network. Embedded generators are generators that are able to connect in parallel to Ausgrid's network. Types of generators may include inverter energy systems (such as solar PV and batteries), as well as rotating machines (such as synchronous and asynchronous turbines/alternators).

This standard is primarily focussed on anti-islanding protection requirements, along with select other technical requirements which are related to protection, or are often implemented using the same equipment (eg voltage and power quality control). There are differing requirements depending on generator type and rated capacity.

It also covers earthing requirements for embedded generators, and establishes technical review and approval requirements based on type of generator connection.

3.0 SHORT CIRCUIT PROTECTION

The requirements for embedded generator short circuit protection systems are not covered in this standard. Further information can be found in AS/NZS 3000, NSW Service & Installation Rules, and the National Electricity Rules.

4.0 FAULT LEVELS AND SCHEDULING

In some parts of Ausgrid's network, addition of new embedded generation could result in fault levels becoming greater than switchgear and equipment ratings.

Ausgrid therefore reserves the right to prohibit the connection of a generator where Ausgrid's network may become compromised under high-fault level or abnormal conditions. In some locations, connection may be allowed with the additional provision of a control signal from Ausgrid that results in the generating unit being either taken off-line (ie a 'soft-trip') or inhibited from starting up. Also see Section 9.9 – Communications Link.

Upon assessment of the proposed connection, Ausgrid will advise the proponent if any fault level issues exist whereby scheduling may be required as part of the installation.

5.0 SYDNEY CBD NETWORK

Sydney CBD's triplex network is different to other parts of the Ausgrid distribution area and, due to its complexity will impose different restrictions on the installation of embedded generation. Ausgrid will identify if any restrictions are necessary as part of review of the connection application.

6.0 STANDBY GENERATORS

Standby generators which will never operate in parallel with the Ausgrid's network are covered in Section 8.3 of the NSW Service & Installation Rules, to which there are no additional requirements as a result of this standard.

Standby generators which are paralleled with Ausgrid's network for a short time before the installation is disconnected from the grid shall comply with Section 8.4 of the NSW Service & Installation Rules as Synchronise Close Transfer Trip (SCTT) generators (sometimes referred to as bumpless transfer generators, or short time transfer generators).

There are no additional anti-islanding requirements for these types of generators, however for SCTT generators above 30kVA a technical review by Ausgrid is required to confirm that the possible fault level contribution will not result in equipment ratings being exceeded in the surrounding network.

7.0 INVERTER ENERGY SYSTEMS

7.1 General

Inverter Energy Systems are comprised of one or more power sources (eg solar PV, batteries) connected through one or more inverters to the same electrical installation.

Inverter Energy Systems to be connected to Ausgrid's network must comply in the first instance with all requirements of AS/NZS 4777.1:2016, and consist only of inverters compliant with AS/NZS 4777.2:2015. An IES shall also be constructed only by a Clean Energy Council certified installer.

This standard only defines specific requirements for connection of these systems to Ausgrid's network which are variations of, or additional to AS/NZS 4777.

A list of AS/NZS 4777.2 approved inverters can be found on the Clean Energy Council's website: https://www.cleanenergycouncil.org.au

7.2 Small inverter connections (inverter energy systems of 30kVA or less)

As a limited variation to AS/NZS 4777, Ausgrid will allow for a total IES capacity of up to 10kVA to be connected to a single phase.

Note 1: This allowance can be considered to negate the AS/NZS 4777 requirement for phase balance centralised protection for an IES smaller than 30kVA. Above 30kVA phase balance protection is required exactly as prescribed in AS/NZS 4777.

Note 2: IES capacity is based on inverter nameplate rating, and will be assessed as such without reference to the use of export limiting controllers.

Note 3: In some cases Ausgrid may allow additional inverter capacity (eg battery inverters) to be installed on a single phase such that the 10kVA limit is exceeded.

7.3 Centralised protection (inverter energy systems greater than 30kVA)

For an IES above 30kVA, AS/NZS 4777.1:2016 requires the implementation of centralised protection.

For connection to Ausgrid's network, the centralised protection of an IES of above 30kVA shall also incorporate the following anti-islanding elements (set as per Annexure C – Protection Set Point Limits):

- Rate of Change of Frequency (ROCOF), and
- Vector Shift (VS).

An installation shall be deemed to meet the location requirements of centralised protection if it obtains measured input values (eg voltage, current) which are upstream (ie closer to the point of connection) than all inverters connected at the installation.

Suitable test and isolation links shall be provided on all inputs and outputs of the centralised protection device to allow secondary injection testing without the need to disconnect and then re-terminate wires.

For installations with a HV connection point, the centralised protection shall also implement Neutral Voltage Displacement protection as described in Section 9.6. Devices used to implement centralised protection in these cases shall be compliant with IEC 60255.

7.4 Inverter energy systems greater than 200kVA

For connection of an IES of capacity greater than 200kVA, all requirements of AS/NZS 4777.1:2016 shall be met.

In addition to the Australian Standard, Ausgrid's requirements for anti-islanding protection will apply as per Chapter 9 – Anti-Islanding Protection, and Annexure A – IES Protection Summary.

7.5 Inverter power quality settings

As a limited variation to AS/NZS 4777, Ausgrid will allow for inverter and centralised protection sustained average overvoltage set-point to be increased to a maximum of 258 V (RMS).

All Inverter Energy Systems to be connected shall be comprised of inverters capable of Volt-Watt and Volt-VAR power quality response modes outlined in AS/NZS 4777.2:2015 and shall have them both enabled.

All inverters shall have Volt-Watt response mode (as outlined in AS/NZS 4777.2:2015) enabled with the following settings applied:

Table 1: Volt-Watt response mode settings

Reference	Voltage	Maximum Value P/Prated (%)
V1	207	100%
V2	220	100%
V3	248	100%
V4	258	20%

All inverters shall have Volt-VAR response mode (as outlined in AS/NZS 4777.2:2015) also enabled with the following settings applied:

Table 2: Volt-VAR response mode settings

Reference	Voltage	VAR % of rated VA	Power Factor
V1	207	60% leading	0.8 leading
V2	220	0	Unity
V3	248	0	Unity
V4	258	60% lagging	0.8 lagging

8.0 ROTATING MACHINES

8.1 General

In the first instance, synchronous and asynchronous rotating machines to be connected to Ausgrid's network must comply with the protection requirements of the Service and Installation Rules of NSW, Section 8 – Alternative Sources of Supply.

For additional guidance on the connection of rotating machine generators, see NS194B - Guidelines for Rotating Machines Connected to the Ausgrid Network.

For embedded rotating generators of above 30kVA, Ausgrid's requirements for anti-islanding protection will apply as per Chapter 9 – Anti-Islanding Protection, and Annexure B – Rotating Machine Protection Summary.

8.2 Check synchronisation

Synchronous machines shall only be able to be paralleled to Ausgrid's network if their control device performs Check Synchronisation (CS) to verify the machine is in synchronism with Ausgrid's network. See also Section 9.8 – Connection, Reconnection and Synchronisation.

9.0 ANTI-ISLANDING PROTECTION

9.1 General

The following anti-islanding protection design requirements are applicable to all Inverter Energy Systems of greater than 200kVA, and for all rotating machines of greater than 30kVA.

Ausgrid's protection element requirements for these types of connections are tabulated in Annexure A – IES Protection Summary, and Annexure B – Rotating Machine Protection Summary.

9.2 Redundancy and circuit breaker fail

The anti-islanding protection system shall include sufficient redundancy to ensure that the generator/s disconnect from the network with any single protection element out of service. This may include but is not limited to relays, circuit breakers, and power supplies.

This will typically require 'Main' and 'Backup' protection schemes. The system shall also make allowance for circuit breaker fail (CBF) scenarios in their design.

CBF protection may be achieved by having the Main and Backup schemes operate independent circuit breakers/contactors. See also Section 9.7 – Fail-Safe.

NOTE: It is generally preferable for both Main and Backup anti-islanding protection to disconnect the generator only, and not isolate other loads in the electrical installation.

Inverter energy systems – Main protection

Due to the AS/NZS 4777.2:2015 requirements for inverter anti-islanding and disconnection functions, compliant inverters are considered to provide the 'Main' protection.

Centralised protection (as per Section 7.3) may be designed in such a way that it also meets the redundancy/CBF requirements of this section.

9.3 Voltage and frequency limits

Voltage and frequency limits and delay values for Inverter Energy Systems are as detailed in AS/NZS 4777.

Ausgrid's allowable ranges for these elements for rotating machines are detailed in Annexure C – Protection Set Point Limits.

Suitable voltage settings for HV operating generators shall be negotiated on a case-by-case basis.

9.4 Export embedded generators

For generators that are intended to export power to Ausgrid's network, the following protection elements shall be implemented as part of the anti-islanding protection:

- Intertripping, and/or
- Vector Shift (VS) and Rate of Change of Frequency (ROCOF).

See Annexure A – IES Protection Summary, Annexure B – Rotating Machine Protection summary, and Annexure C – Protection Set-Point Limits.

Intertripping is preferred (see also Section 9.9), and may be mandated as a requirement for some sites as part of a technical review by Ausgrid.

Primary anti-islanding testing as per Section 10.4 shall be done to confirm the adequacy the Vector Shift and ROCOF settings. In some cases, this testing may identify the need for more sensitive settings.

NOTE: The proponent must accept that Vector Shift and ROCOF protection may trip for system disturbances and fault events both within and external to the local network that the generator is connected to. Experience has shown setting of these schemes to be difficult to avoid nuisance tripping while providing adequate protection.

9.5 No-export embedded generators

For generators which are not intended to export power to Ausgrid's network, the following protection elements shall be implemented as part of the anti-islanding protection:

- Grid Low Forward Power (GLFP), and/or
- Grid Reverse Power (GRP).

NOTE: Grid Reverse Power Protection is not the same as Generator Reverse Power Protection.

See Annexure A – IES Protection Summary, and Annexure B – Rotating Machine Protection Summary.

Settings and details of Grid Low Forward/Reverse Power protection shall be negotiated with Ausgrid on a case-by-case basis.

In circumstances where reverse power and low forward power are not suitable for use with No Export Generators, Intertrip or Vector Shift and ROCOF protection, as per Export Embedded Generator requirements, may be used by agreement with Ausgrid.

9.6 Neutral voltage displacement

Embedded generator installations with a high voltage connection point to Ausgrid's network shall implement Neutral Voltage Displacement (NVD) protection.

For embedded generator installations with a low voltage connection point, NVD is not mandatory unless it is made a site specific condition by Ausgrid as part of technical review.

Suitable NVD settings will be negotiated with Ausgrid on a case-by-case basis.

Informative note:

Considering the earthing arrangements and the use of delta-star transformer windings throughout Ausgrid's distribution network, detection of an 11kV (or other distribution voltage) network earth-fault on the delta-side of the transformer may be problematic for generator installations.

While the fault-current contribution from Ausgrid will be interrupted by the opening of appropriate circuit-breakers, there remains the possibility that a generator may still energise the faulted

distribution network without fault current flowing (due to the loss of Ausgrid's earth reference). As such, the generator must not remain connected to the system if this type of situation arises because of the safety and legal implications.

The most reliable detection technique for this situation is Neutral Voltage Displacement using voltage transformers (VT's) connected to the 11kV system (or other high voltage as required). Particular attention is needed to confirm that the VT's are of the correct configuration/type for use with this form of protection.

For installations that have a low voltage connection point, it is acknowledged the proponent will not readily have access to a suitable location at which to install the high voltage VT's necessary for NVD. The location and responsibility of installing VTs will be negotiated during the assessment process.

9.7 Fail-Safe

Unless the requirements outlined in points (i) and (ii) below are met, the relay power supplies, tripping and circuitry associated with the anti-islanding protection systems shall be fail safe. That is any failure of any part of the system shall result in the generator being disconnected and unable to be re-connected to Ausgrid's network.

Therefore, circuit breakers with shunt trips are not acceptable. Where AC (or DC) supplies are proposed to be used, normally open contactors held in by healthy AC (or DC) volts or undervoltage release of circuit breakers on loss of AC (or DC) supply, relay fail and system fail shall be required.

Alternate arrangements, usually only associated with HV connections, such as a DC system utilising shunt trip circuit breakers for the network and anti-islanding systems may be accepted with approval by Ausgrid, providing the following 2 points are met.

(i) The proponent has an approved Installation Safety Management Plan.

(ii) Requirements for the ongoing inspection, maintenance and testing of the network and anti-islanding protection systems are specified within the Connection Agreement.

9.8 Connection, reconnection and synchronisation

The device controlling generator connection to the grid shall verify normal supply conditions on the grid for all connected phases (ie all three phases for a three phase connection) for a period of at least 1 minute prior to the device enabling connection.

Either synchronisation or zero voltage on the generator side of the switching point shall be confirmed before the generator is paralleled to Ausgrid's network.

When these conditions are met, automatic reconnection is permitted.

Where there are multiple points of automatic reconnection in the installation, each point shall independently monitor and verify normal supply conditions on the grid for all connected phases for a period of at least 1 minute before enabling automatic reconnection.

In some installations, as will be nominated by Ausgrid, a manual reset may be required and the generator will not be allowed to be automatically reconnected to the network. Ausgrid will negotiate the requirements of these proposals on a case by case basis with the proponent.

9.9 Communications link

If a communication link is installed between the embedded generator and Ausgrid to facilitate an intertrip or scheduling, or within the electrical installation as part of the anti-islanding protection, it shall be continuously monitored for integrity. In the event that the communication link fails then the generator shall be automatically disconnected until the link is restored.

Where a fail-safe intertrip design is used to meet the requirements of Section 9.4 – Export Generator Requirements, duplication of the link is not required.

9.10 Relay requirements

Relays and devices used to meet the requirements of Chapter 9 of this standard (ie for IES of greater than 200kVA, and for rotating machines) shall be approved by Ausgrid. A list of pre-approved relays and their available functions can be found on Ausgrid's website: https://www.ausgrid.com.au/ASPs-and-Contractors/Technical-documentation/Network-Standards

For HV-connected installations, at least one layer of protection (backup or main) shall be compliant with the appropriate severity class of IEC 60255.

9.11 Testing and verification facilities

Inputs and outputs of anti-islanding protection relays shall be provided with suitable facilities to allow secondary injection testing of the relay to be undertaken without the need to disconnect and re-terminate wires. This includes:

- Isolation links on protection relay AC measurement inputs,
- Isolation links in series with protection relay contact outputs, and
- Test injection and measurement points compatible with 4 mm banana plugs. Measurement points shall be available on both sides of relay contacts.

All protection cabling shall be appropriately labelled, and the labels shall corroborate with all drawings and documentation provided in the Protection Design Pack.

10.0 PROTECTION DESIGN REVIEW AND COMMISSIONING

10.1 General

Ausgrid has different requirements for anti-islanding protection design review and commissioning depending on the embedded generator size and type.

The following review and testing requirements are in addition to testing to applicable Australian Standards and the Service & Installation Rules of NSW.

10.2 Commissioning of embedded generation of 30kVA or less

No additional approval of protection is needed as a result of this standard.

10.3 Commissioning IES of greater than 30kVA, up to 200kVA

The following outlines the approvals required for IES in this range for installations with a LV connection point.

Design approval

The anti-islanding protection design shall be reviewed and approved by an appropriately qualified designer with relevant experience with AS/NZS 4777.1:2016, AS/NZS 4777.2:2015, and this standard (NS194). A complete Protection Design Pack (see Annexure D – Protection Design Pack) shall be submitted as part of the connection application for record keeping and auditing.

Commissioning

In addition to all testing and commissioning requirements of AS/NZS 4777.1, and AS/NZS 4777.2, secondary injection testing of the centralised protection relay shall be carried out on-site to confirm the system meets the requirements of AS/NZS 4777.1:2016, including but not limited to failsafe, tripping logic, and protection element accuracy.

The secondary injection testing shall be carried out by a qualified electrical tester with calibrated test equipment, and the results shall be recorded in a test report along with the results of testing detailed in AS/NZS 4777.1:2016, 7.6 – Commissioning.

The test report will be signed by the qualified electrical tester. This report shall be provided to Ausgrid for record keeping.

Inspections and compliance auditing

The proponent shall make arrangements for the inspection by an Ausgrid Installation Inspector to coincide with the secondary injection testing.

Ausgrid reserves the right to audit any designs and testing used for embedded generation connection to its network. In accordance with Ausgrid's Customer Installation Safety Plan an embedded generator may be inspected for electrical safety, compliance with the relevant standards and consistency with supplied design information at any time.

Where a major defect is identified, the IES shall be disconnected until the defect is rectified and the installation is reinspected to the satisfaction of Ausgrid. Where a minor defect is identified Ausgrid's standard defect process shall be followed.

If reinspection of an IES is required it will incur a reinspection fee in accordance with Ausgrid's Connection Policy – Connection Charges document.

10.4 Commissioning IES of above 200kVA, rotating machines, and HV connected installations

For IES of above 200kVA, IES of between 30kVA to 200kVA with a HV connection point, and for rotating machine connections above 30kVA, Ausgrid will carry out a technical review of the anti-islanding protection to assess compliance with this standard.

Design approval

Following receipt of the proponent's complete Protection Design Pack (see Annexure D), Ausgrid will conduct a technical review to confirm compliance with this standard, and to identify the need for any site specific conditions.

Commissioning

Following design approval, the proponent shall provide Ausgrid with an appropriate test plan to be used for commissioning. Ausgrid shall inform the proponent if the plan is adequate, or if any changes are needed to confirm that the generator's anti-islanding protection systems are adequately tested.

The proponent shall arrange with Ausgrid for an Ausgrid representative to be present for all testing relating to the anti-islanding protection. The testing shall include at a minimum:

- Secondary injection testing of relay logic, failsafe, and set point accuracy,
- Correct operation of all disconnection devices (tested prior to generator connection to the grid),
- Scheme logic, synchronisation, and reconnection procedure, and
- Primary anti-islanding testing.

An appropriate method of primary anti-islanding testing will depend on the characteristics of the generator and the electrical installation. Proponents should note that primary anti-islanding testing will often require the switching of a significant amount of active load, which may necessitate disruptions to normal electrical supply in the electrical installation.

Proponents shall allocate sufficient time to allow test plan review and resource allocation by Ausgrid. Ausgrid accepts no liability or warranty for any designs or equipment as part of the design approval or witness testing process.

11.0 EARTHING

11.1 General

The proponent is required to confirm that the generator installation has an earthing system that has been designed to limit any step, touch and transferred potentials to safe values using the principles detailed in "ENA EG-0:2012 – Power System Earthing Guide Pt1: Management Principles".

Equipment used to interface to the distribution network (eg step up transformer or circuit breaker) shall comply with NS116 – Design Standards for Distribution Earthing.

Additionally the earthing system of the Generator shall be designed to limit the voltages impressed onto surrounding utility infrastructure under earth fault conditions. For metallic pipelines the tolerable voltages are listed in AS/NZS 4853:2012 and for telecommunications assets the voltage limits are found in AS/NZS 3835:2006.

Generation schemes working in parallel with the distribution network in effect become an integral part of the electricity distribution network. Therefore neutral earthing arrangements for the private generators and any interconnection transformers shall be designed to suit the requirements of both the distribution network and the electrical installation and details provided to Ausgrid.

11.2 Low voltage generators

Generators connected to the network via a delta/star transformer with the delta on the network side may have their neutral directly connected to earth (ie via an MEN link).

Effective isolation of this neutral may be required to inhibit the flow of harmonics through the neutral and the generator's method to limit harmonics may be discussed and agreed to by Ausgrid. The use of 4-pole switching may be required if the generator can operate in standby mode.

11.3 High voltage generators

The generator's high voltage star point shall be effectively isolated from earth (ie isolated or earthed via a high impedance) to avoid any earth fault contributions flowing into the Ausgrid system and to inhibit the flow of harmonic currents through the neutral. Each case will be discussed with the proponent on its merits.

12.0 MULTIPLE EMBEDDED GENERATOR SYSTEMS

12.1 Mixed embedded generator systems

Where a combination of embedded IES and rotating machines are connected at an electrical installation, they shall meet the requirements of this standard for the respective generator type of capacity equal to the total nameplate rating of all embedded generator types connected there.

NOTE: For example, if a 150kVA rotating machine is to be connected to an electrical installation which already has a 60kVA IES installed, the anti-islanding protection for the rotating machine and IES shall meet the requirements of this standard for a rotating machine greater than 200kVA, and an IES greater than 200kVA, respectively.

12.2 Centralised backup protection

Where multiple generator units are embedded in an electrical installation with a total capacity of greater than 30kVA, there shall be at least one layer of anti-islanding protection meeting the relevant requirements of this standard (Section 7.3 for IES of up to 200kVA, otherwise Chapter 9 for other types), the operation of which results in the disconnection of all embedded generators in the electrical installation.

12.3 Existing embedded generators

Where an electrical installation already has embedded generation installed, and new generating sources are proposed to be connected, the entire installation shall comply with this standard. This may require upgrading or retrofitting existing protection systems.

13.0 ALTERATION TO APPROVED DESIGN

The premises owner or occupier shall not modify the approved design or protection setting of the embedded generator without informing and receiving prior written authorisation from Ausgrid.

Upon receipt of a written request to modify the approved design and/or settings, Ausgrid will advise the proponent if it is considered necessary to undertake a new technical assessment on the impact on Ausgrid's network.

If a new technical assessment is required then it will be charged in accordance with Ausgrid's Connection Policy–Connection Charges document.

14.0 AUTHORITIES AND RESPONSIBILITIES

For this network standard the authorities and responsibilities of Ausgrid employees and managers in relation to content, management and document control of this network standard can be obtained from the Company Procedure (Network) – Production / Review of Engineering Technical Documents within BMS. The responsibilities of persons for the design or construction work detailed in this network standard are identified throughout this standard in the context of the requirements to which they apply.

15.0 RELATED DOCUMENTS

15.1 General

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards. Current Network Standards are available on Ausgrid's Internet site at www.ausgrid.com.au.

15.2 Ausgrid documents

- Bush Fire Risk Management Plan
- Company Form (Governance) - Network Technical Document Endorsement and Approval
- Company Procedure (Governance) - Network Technical Document Endorsement and Approval
- Company Procedure (Network) – Network Standards Compliance
- Company Procedure (Network) - Production / Review of Engineering Technical Documents within BMS
- Connection Policy - Connection ChargesNS116 Design Standards for Distribution Earthing
- Electrical Safety Rules
- Electricity Network Safety Management System Manual
- Generator Connection Agreement: General Conditions
- NS116 Design Standards for Distribution Earthing
- NS238 Supply Quality
- Public Electrical Safety Awareness Plan

15.3 Other standards and documents

- AS 2467:2008 Maintenance of electrical switchgear
- AS/NZS 3000:2018 Electrical installations

- AS/NZS 3008.1.1:2017 Electrical installations – Selection of cables
- AS/NZS 3010:2017 Generating sets
- AS/NZS 3017:2007 Electrical installations – Verification guidelines
- AS/NZS 4777.1:2016 Grid connection of energy systems via inverters – Installation requirements
- AS/NZS 4777.2:2015 Grid connection of energy systems via inverters – Inverter requirements
- AS/NZS 5033:2014 Installation and safety requirements for photovoltaic (PV) arrays
- AS 60038:2012 Standard voltages
- AS/NZS 61000.3.2 – Electromagnetic compatibility (EMC) – Limits for harmonic current emissions
- IEC 60255 Measuring relays and protection equipment – multiple parts
- IEC TR 61000.3.6:2012 Electromagnetic compatibility (EMC)-Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
- IEC TR 61000.3.7:2012 Electromagnetic compatibility (EMC)-Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems
- SA/SNZ TR IEC 61000.3.14:2013 Electromagnetic compatibility (EMC)-Limits - Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems

15.4 Other standards and documents

- Australian Clean Energy Council website (https://www.cleanenergycouncil.org.au)
- ENA Doc 001-2008 National Electricity Network Safety Code
- ENA EG-0:2012 Power System Earthing Guide Pt 1: Management Principles
- ENA Guideline for the preparation for connection of Embedded Generation within Distribution Networks – 2011
- National Electricity Rules
- Service & Installation Rules of NSW.

15.5 Acts and regulations

- Electricity Supply (General) Regulation 2014 (NSW)
- Electricity Supply (Safety and Network Management) Regulation 2014
- Work Health and Safety Act 2011 and Regulation 2017.

16.0 DEFINITIONS

Active anti-islanding	A method of preventing islanding by actively varying the output of the inverter.
Anti-islanding protection	An automatic system intended to prevent embedded generators from creating an islanding condition.
Accredited Service Provider (ASP)	An individual or entity accredited by the NSW Department of Planning and Environment, Energy, Water and Portfolio Strategy Division, in accordance with the Electricity Supply (Safety and Network Management) Regulation 2014 (NSW).
Business Management System (BMS)	An Ausgrid internal integrated policy and procedure framework that contains the approved version of documents.
Capacity	Total nameplate rating of all generators to be connected to the electrical installation.
Connection Point	The agreed point of supply established between Ausgrid and a customer's electrical installation.
Document control	Ausgrid employees who work with printed copies of document must check the BMS regularly to monitor version control. Documents are considered "UNCONTROLLED IF PRINTED", as indicated in the footer.

Electrical installation	A customer or strata owned electrical network and/or reticulation system, connected to Ausgrid's network at a Connection Point.
Embedded generation	One or more electrical sources of supply which are capable of being connected to and run in parallel with Ausgrid's network.
Fault level	The maximum possible magnitude of fault current that may occur in a certain electrical installation or network due to a short circuit fault.
Grid	Ausgrid's network.
High voltage (HV)	A voltage exceeding 1,000V.
Inverter	A device that uses semiconductor devices to transfer power between a DC source or load and an AC source or load.
Inverter Energy System (IES)	A system comprising of one or more inverters together with one or more energy sources (which may include batteries for energy storage), and controls.
Islanding	Energisation of an electrical installation and/or the surrounding network by generators without energisation from Ausgrid's network.
Low voltage (LV)	Ausgrid's standard service voltage, nominally 230V.
Network Standard	A document, including Network Planning Standards, that describes the Company's minimum requirements for planning, design, construction, maintenance, technical specification, environmental, property and metering activities on the distribution and transmission network. These documents are stored in the Network Category of the BMS repository.
Review date	The review date displayed in the header of the document is the future date for review of a document. The default period is three years from the date of approval however a review may be mandated at any time where a need is identified. Potential needs for a review include changes in legislation, organisational changes, restructures, occurrence of an incident or changes in technology or work practice and/or identification of efficiency improvements.
Rotating Machine	A synchronous or asynchronous rotating machine generator, eg a gas/ diesel/ wind turbine
Scheduling	Inhibiting the operation of an embedded generator fully or partially due to network conditions or to contain fault levels.
Short circuit protection	An automatic system intended to protect an electrical installation or network by isolating short-circuit faulted equipment.
Site Specific Condition	A condition or requirement imposed on a connection that is particular to those premises.

17.0 RECORDKEEPING

The table below identifies the types of records relating to the process, their storage location and retention period.

Table 3: Recordkeeping

Type of Record	Storage Location	Retention Period*
Approved copy of the network standard	BMS Network sub process Standard – Company	Unlimited
Draft Copies of the network standard during amendment/creation	HPRM Work Folder for Network Standards (HPRM ref. 2014/21250/93)	Unlimited
Working documents (emails, memos, impact assessment reports, etc.)	HPRM Work Folder for Network Standards (HPRM ref. 2014/21250/93)	Unlimited

* The following retention periods are subject to change eg if the records are required for legal matters or legislative changes. Before disposal, retention periods should be checked and authorised by the Records Manager.

18.0 DOCUMENT CONTROL

Content Coordinator : Manager Secondary Systems

Distribution Coordinator : Senior Engineer – Guidelines, Polices and Standards

Annexure A – IES Protection Summary

Table A1: IES greater than 200kVA backup protection requirements (see Note 2)

Protection and Associated Reference	Reference Section	Low Voltage Connection Point (415V)	High Voltage Connection Point (11kV and above)
Common Requirements			
Neutral Voltage Displacement	9.6	If required	M
Under voltage and Overvoltage	9.3	M	M
Under frequency and Over frequency	9.3	M	M
No Export Generator Requirements (Note 1)			
Grid Reverse Power	9.5	M1 (P)	M1 (P)
Grid Low Forward Power	9.5	M2	M2
Export Generator Requirements			
Intertrip	9.4, 9.9	M1 (P)	M1 (P)
ROCOF and Vector Shift	9.4	M2	M2

Legend

M: Mandatory

M1, M2 Mandatory with alternative - either ‘M1’ or ‘M2’ to be agreed to. Option marked with (P) is preferred.

Note 1: In circumstances where reverse power and low forward power are not suitable for use with No Export Generators, Intertrip or Vector Shift and ROCOF protection, as per Export Generator Requirements, can be provided by agreement with Ausgrid.

Note 2: AS/NZS 4777 compliant inverters provide the main protection, so the protection functions listed are the back-up protection requirements only.

Annexure B – Rotating Machine Protection Summary

Table B1: Rotating machines greater than 30kVA protection requirements

Protection and Associated Reference	Reference Section	Low Voltage Connection Point (415V)	High Voltage Connection Point (11kV and above)
Common Requirements			
Neutral Voltage Displacement	9.6	If required	M
Duplicate Under voltage and Overvoltage	9.3	M	M
Duplicate Under frequency and Over frequency	9.3	M	M
Check Synchronisation*	8.2, 9.8	M	M
No Export Generator Requirements (Note 1)			
Grid Low Forward Power (main) and Grid Reverse Power (backup) implemented in separate relays.	9.5	M1 (P)	M1 (P)
Duplicate Grid Reverse Power	9.5	M2	M2
Export Generator Requirements			
Intertrip	9.4, 9.9	M1 (P)	M1 (P)
Duplicate ROCOF and Vector Shift	9.4	M2	M2

Legend

M	Mandatory
M1, M2	Mandatory with alternative - either ‘M1’, ‘M2’ to be agreed to. Option marked with (P) is preferred by Ausgrid.

* Asynchronous machines do not require synchronising facilities.

Note 1: In circumstances where reverse power and low forward power are not suitable for use with No Export Generators, Intertrip, Vector shift and ROCOF protection, as per the Export Generator Requirements, can be provided by agreement with Ausgrid.

Annexure C – Protection Set-Point Limits

The following table defines the outer limits that will be considered acceptable for Main or Backup anti-islanding protection. Set-points may be chosen as required to suit the proponent's generator/installation within these limits. Tested accuracy should be based on manufacturer's specification, however it shall not exceed +/- 2% for voltage based elements, +/- 1% for frequency based elements, and +/- 5% for time delays (smaller accuracy tolerances may be required in some instances for grading purposes).

Appropriate settings for HV OV/UV protection shall be negotiated with Ausgrid when required.

Main protection settings are to be at least as sensitive and at least as fast as the Backup protection settings.

Table C1: Protection elements and set-point limits

Protection Element	Pickup	Delay
Inverter Energy Systems		
Over Voltage (OV)	As per AS/NZS 4777	
Under Voltage (UV)		
Over Frequency (OF)		
Under Frequency (UF)		
Rotating Machines		
Over Voltage (OV)	260 V	2 s
Under Voltage (UV)	200 V	2 s
Over Frequency (OF)	52 Hz	2 s
Under Frequency (UF)	48 Hz	2 s
All generator types as required		
Rate of Change of Frequency (ROCOF)	1 Hz/s	1 s
Vector Shift (VS)	8 degrees (strong/urban network)	0 s
	12 degrees (weak/rural network)	
Grid Reverse Power (GRP)	Negotiated during assessment	
Grid Low Forward Power (GLFP)	Negotiated during assessment	
Neutral Voltage Displacement (NVD)	Negotiated during assessment	

Annexure D – Protection Design Pack

The following anti-islanding protection details and drawings must be submitted to Ausgrid for all embedded generation connections greater than 30kVA:

(a) A statement indicating whether or not the facility will export to the network.

(b) A 3 phase AC schematic diagram of protection and control systems. Main and backup protection set-points should also be tabled on this drawing for ease of comparison (this includes relevant inverter set-points).

(c) DC schematic diagram (where applicable) of all protection schemes and associated logic.

(d) Details of primary and secondary interfaces to the network.

(e) Details of all protection and metering CTs and VTs, including:

- Connections to protection relays and other equipment.
- Available ratios (eg 1000-500/1).
- Connected ratio (eg 500/1).
- Class (eg 10P20, 5 VA on 500/1)
- Applicable standard (eg AS1675, AS60044.1, AS60044.2).

(f) Details of the protection relay(s) being proposed, including:

- Manufacturer.
- Full model number / order code showing selected options.
- Full settings list of all configurable set-points as intended to be programmed.

(g) Details of all circuit breakers and contactors which form part of the scheme, including:

- Manufacturer.
- Model number.
- Coil burden(s).
- Continuous contact rating.
- Fault break rating (circuit breakers).

(h) Inverter details (if used), including at a minimum:

- Manufacturer.
- Model number.
- Compliance with AS/NZS4777.2 and any adjusted settings.

It shall be possible from review of the Protection Design Pack to determine the full behaviour of the scheme without ambiguity. The relationship between protection device inputs, protection device elements, protection device output contacts and switchgear shall be clear and readily apparent.

All drawings shall be appropriately titled, revision controlled, and marked with the name and contact details of the responsible engineer.

Annexure E – Example Single Line Diagrams

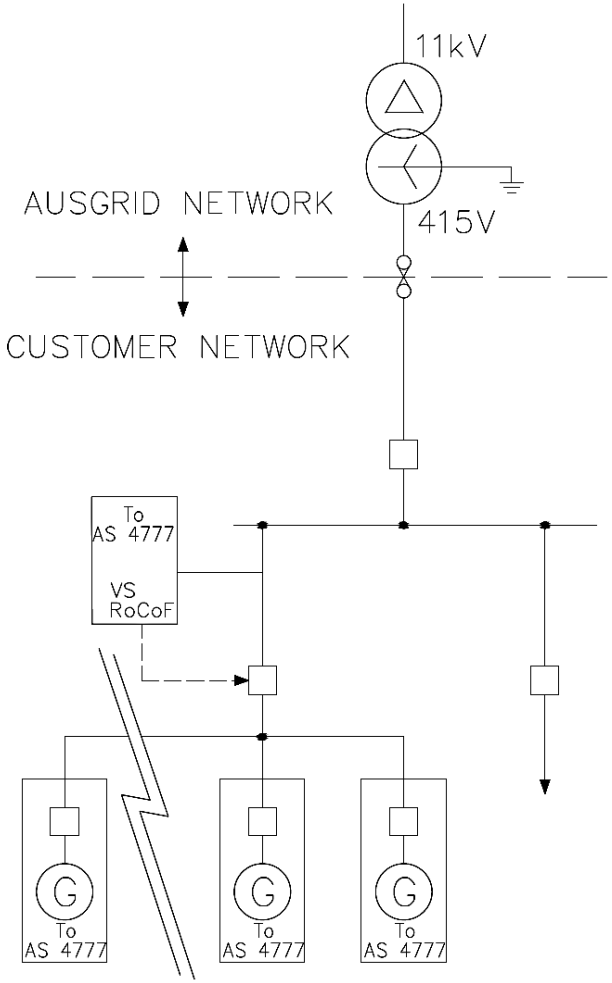

Figure F1: LV connection point, IES with centralised protection

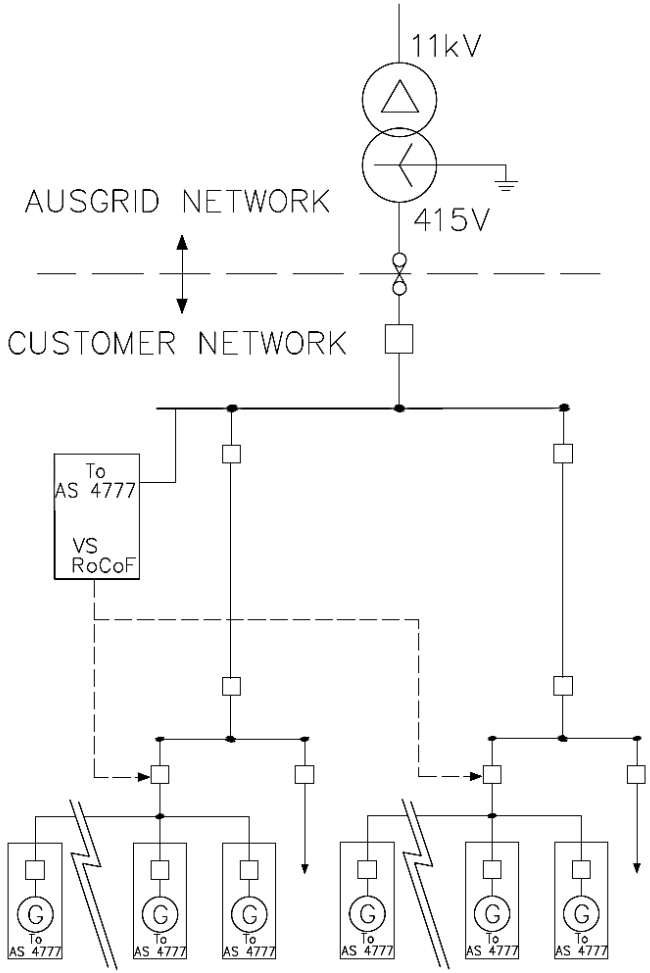

Figure F2: LV connection point, IES with centralised protection across multiple switchboards

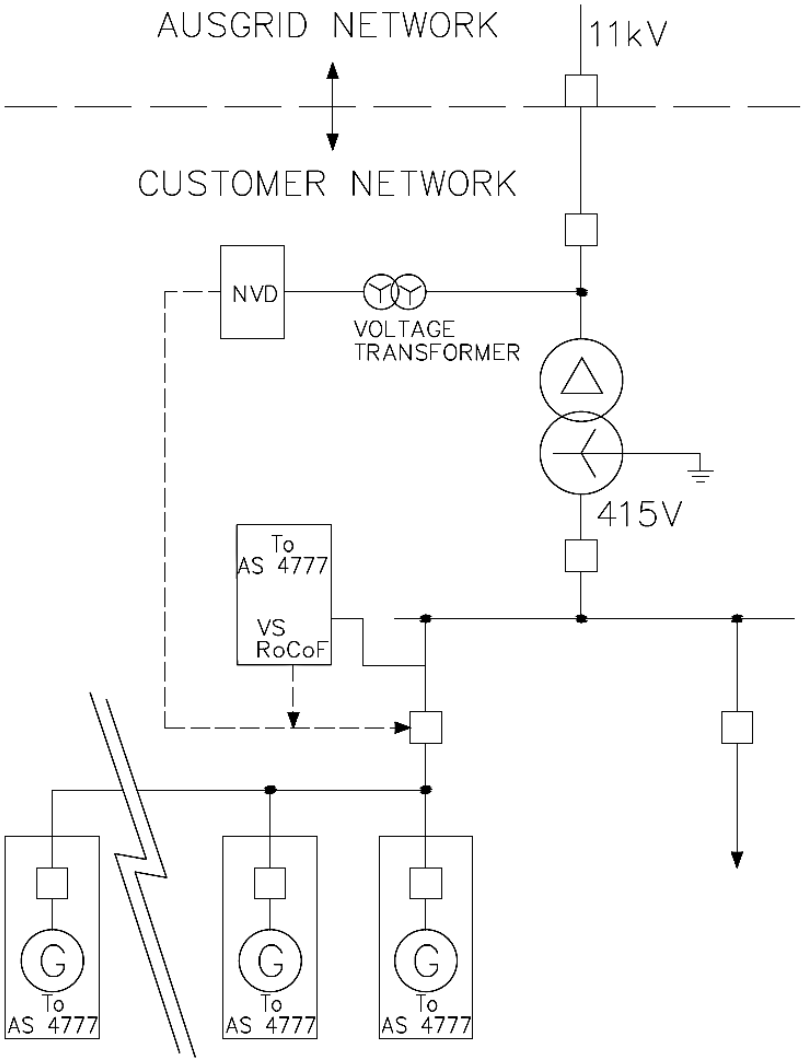

Figure F3: HV connection point, IES with centralised protection

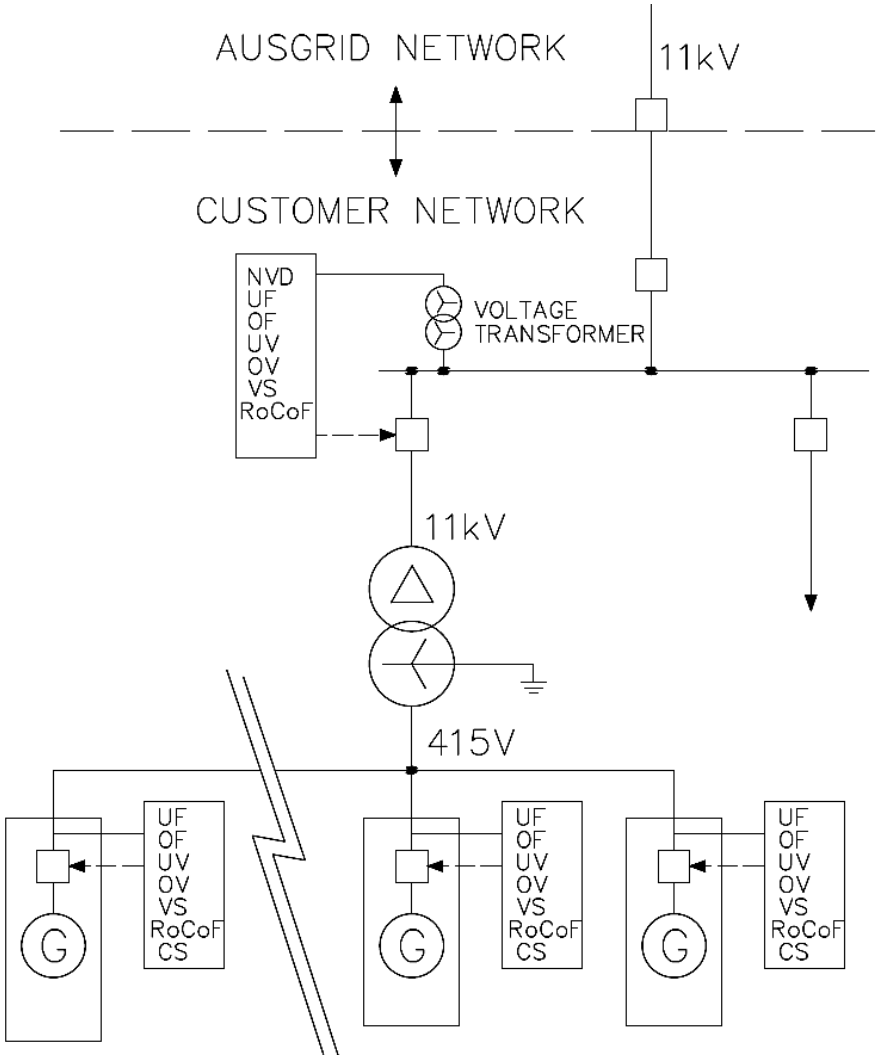

Figure F4: HV connection point, Export Rotating Machines

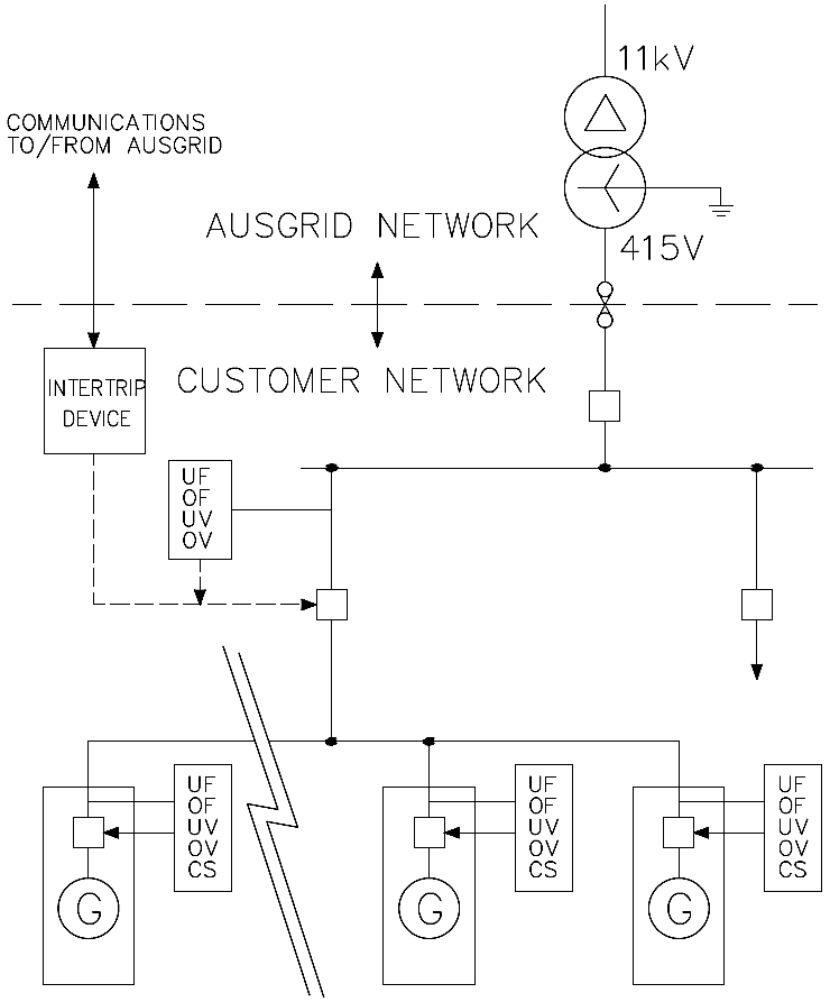

Figure F5: LV connection point, Export Rotating Machines with Intertripping

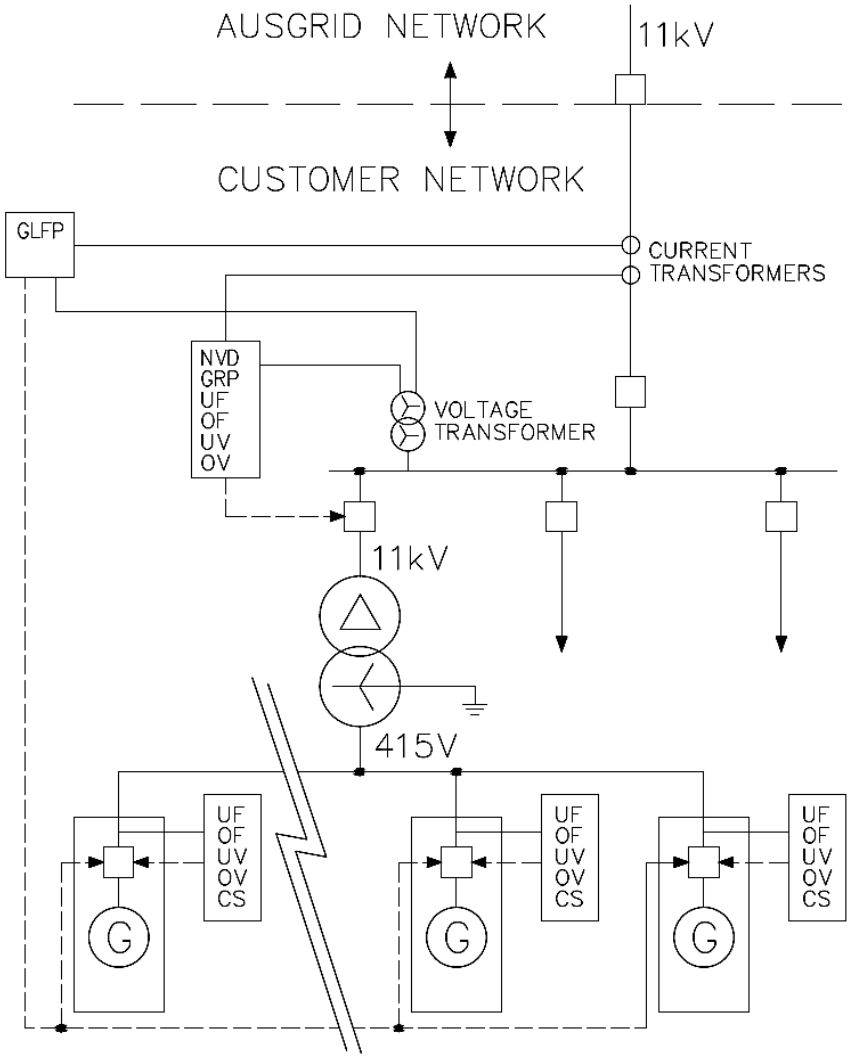

Figure F6: HV connection point, No-Export Rotating Machines